Federal Land Assistance, Management and Enhancement (FLAME) Act Suppression Expenditures for Interior and Agriculture Agencies:

March 2016 Forecasts for Fiscal Year 2016

Supporting Documentation

Report Date: February 19, 2016

Executive Summary

In FY 2016, the U.S. Department of Agriculture Forest Service is forecast to spend:

Median forecast	$1.279 billion
90% confidence range of forecast	$885 million to $1.676 billion
Forecast tercile of historical expenditures since 1985	Upper
Previous median forecast (September 2015 FLAME)	$1.004 billion

These forecasts are reported in Tables 1-3 and Figure 1.

In FY 2016, the bureaus of the U.S. Department of the Interior are forecast to spend:

Median forecast	$350 million
90% confidence range of forecast	$242 million to $458 million
Forecast tercile of historical expenditures since 1985	Middle
Previous median forecast (September 2015 FLAME)	$378 million

The DOI forecast is reported in Tables 4-5 and Figure 2.

Overview

With the passage of the FLAME Act in 2009, both the U.S. Department of Agriculture Forest Service (USDA) and the Department of the Interior (DOI) are required to produce forecasts of annual suppression expenditures three times during each fiscal year: March, May, and July, with a September outlook for the next fiscal year required when the next fiscal year budget is not approved by Congress and the President by that date. Scientists at the USDA Forest Service Southern Research Station provide these forecasts to both the Forest Service and the DOI.

Modeling

Modeling Framework for the March 2016 FLAME Act Forecast of FY 2016 Forest Service Expenditures

To meet the statutory requirements of the FLAME Act, the Forest Service developed statistical models based on peer reviewed research.[1,2] These models have been developed for several forecast horizons and are generally specified as a system of equations. Each of the three equations contained in the current modeling system represents a statistical relationship between historical expenditures and a set of predictor variables for Forest Service regional aggregates. These equations were estimated using ordinary least squares regression (OLS).

This report is the second forecast issued for FY 2016. The current approach forecasts expenditures by Forest Service regional aggregates for West (Regions 1-6), East (Regions 8 & 9), and RFS. The expenditures made by the National Interagency Fire Center, Washington Office, and research stations continue to be modeled as an aggregate, which we label in this report as "RFS." This RFS category is combined with Region 10 (Alaska) because there are relatively few expenditures on suppression in Region 10. This FLAME Act model used for this report differs from the model used in several previous March FLAME Act forecasts in that it models expenditures for regional aggregates rather than individual regions. This regional aggregate approach was chosen for this report because the forecast for the total Forest Service expenditures using this method had a lower forecast error when evaluated over historical data.

The West statistical equation relates spending in the current fiscal year to a dummy variable for structural change starting in FY 2000, lagged measures of drought from January of the current FY (Palmer Z indices), ocean temperatures (Niño-3 sea surface temperature anomaly), and ocean pressure indices (Pacific-North American teleconnection pattern). The East equation has lagged eastern expenditures, Palmer Z index for January and time. The RFS equation includes a dummy variable for structural change starting in FY 2012. The equations had moderate R^2's, ranging from 0.61 (RFS) to 0.80 (West). Durbin-Watson statistics, designed to detect serial autocorrelation in the residuals of estimated equations, were all within the acceptable (insignificant) or inconclusive range.

Forecasts were made using the equation estimates shown in Table 6 for regional aggregate expenditures. Data for modeling were annual fiscal year totals of expenditures and ranged from 1995 to 2015, the only years for which consistent region-level data could be assembled. To erase the effects of general price inflation, all expenditures were deflated to the value of a dollar in 2014 using the gross domestic product deflator used in the President's budget—that is, models were estimated and expenditures were forecast in "real" dollar terms.[3]

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[1] Prestemon, J.P., K.L. Abt, and K. Gebert. 2008. Suppression cost forecasts in advance of wildfire seasons. Forest Science 54(4):381-396.

[2] Abt, K.L., J.P. Prestemon, and K. Gebert. 2009. Wildfire suppression cost forecasts for the US Forest Service. Journal of Forestry 107(4):173-178.

[3] http://www.whitehouse.gov/sites/default/files/omb/budget/fy2016/assets/hist.pdf

After the forecast, we adjusted the forecast values to put them in current dollars. When generating a forecast distribution (see Figure 1), we randomly sampled from equation error distributions in ways that accounted for the uncertainties in the forecast. These Monte Carlo forecasts, which are repeated 50,000 times, do not produce a precise estimate. Rather, they generate a distribution of estimates. This distribution is summarized in many ways: a forecast density distribution, a table reporting a median forecast and the lower and upper bounds of likely observed expenditures, and a table of not-to-exceed expenditures by probability levels. We also describe where the median forecast value for each regional aggregate falls within the observed historical expenditures for other years, in real dollar terms.

Model fitness is reported in Table 7 and Figure 3. Table 7 shows how well the March 2016 FLAME Act forecast model performs by measuring the errors developed from out-of-sample forecasts (produced by dropping the observation of the forecast year, and doing this iteratively over the historical data, a technique sometimes termed "cross-validation") compared with observed expenditures for the Forest Service. The Root Mean Squared Error of the model used in this March 2016 forecast of FY 2016 expenditures, when applied to the 1998-2015 period, was $229 million and it had a negative bias, tending to under-forecast each year, on average, by about $4 million (.39 percent). We do not adjust the current forecast using this bias. The model had a Mean Absolute Percent Error of 19 percent, meaning that the typical forecast averaged 19 percent above or below expenditures actually incurred during the 1998-2015 time span. Finally, this model correctly predicted the direction of change in suppression expenditures by the Forest Service 89 percent of the time. This March FLAME forecast predicts that expenditures in FY 2016 are likely to be lower than expenditures in FY 2015 (Figure 3).

Modeling Framework for the March 2016 FLAME Act Forecast of FY 2016 Department of the Interior Expenditures

The forecast model for the DOI was based on departmental total expenditure data—i.e., aggregated across all bureau and geographic regions—and so involved estimation of a single equation. The March 2016 FLAME Act Model used department-wide expenditures for FY 1985-2015. We modeled aggregate DOI expenditures using a parsimonious model specification, as a function of the Pacific-North American teleconnection pattern, the Niño-3 sea surface temperature anomaly, and a variable to represent years after 2000. This is the same model as was used last year for the March 2015 FLAME Act forecast.

The DOI suppression expenditure forecast equation is reported in Table 8. The estimated equation explained 82 percent of the variation ($R^2 = 0.82$) in annual DOI suppression expenditures over the historical time period, 1985-2015. The Durbin-Watson statistic indicated no evidence (1.97) of residual autocorrelation in the model estimation errors. Uncertainty surrounding the DOI forecast for FY 2016 is illustrated with the probability density graphic (Figure 2) developed with 50,000 Monte Carlo random forecasts.

Model fitness for the March FLAME Act forecast model for DOI is reported in Table 9. The DOI March FLAME Act Forecast Model was evaluated by making cross-validated forecasts of DOI expenditures, then generating the model evaluation diagnostics presented in Table 9. This March forecast model had a Root Mean Squared Error of $65 million when calculated over

1985-2015. The model had a bias of positive $5 million (1.64 percent) calculated over 1985-2015. We do not adjust the forecasts for this bias. The model had a Mean Absolute Percent Error of 20 percent for the 1985-2015 time span. It correctly predicted the direction of change in suppression expenditure for the agency from one year to the next of 82 percent from 1986-2015, and the model predicts that expenditures in 2016 are likely to be lower than observed in FY 2015. (Figure 4).

Results

Both the USDA Forest Service and the DOI are forecast to have fire suppression expenditures in the middle tercile since 1995. However, compared to the longer data series back to 1985, the Forest Service forecast median is in the upper tercile while the DOI forecast median is in the middle tercile. The Forest Service forecast median is slightly higher than the September FLAME Act forecast median while the DOI forecast median in this March FLAME Act forecast is slightly lower; however, both medians are within their respective September FLAME confidence intervals. The changes in outlooks from September may be attributed to the inclusion in the March models of a positive Niño-3 sea surface temperature anomaly, updated localized measures of drought, and a positive Pacific North American Oscillation ocean pressure condition compared to the September FLAME Act forecast model, which, we note, does not include climatic information. Also, the September FLAME Act forecast is submitted prior to the end of the FY 2015 fiscal year and, therefore, only includes actual suppression expenditure data through FY 2014 while this March forecast includes the FY 2015 year-end actual in the model estimation.

USDA Forest Service

The median forecasts for each of the regions, and for the USDA Forest Service total, are reported in Table 1, along with the 80, 90 and 95% confidence intervals. Table 2 contains probabilities of falling below specific dollar amounts by region-aggregate and in total. Table 3 reveals that, when compared to expenditures since 1995, East and RFS aggregates are forecast to be in the upper tercile in 2016; while the West and the USDA Forest Service total are expected to have expenditures in the middle tercile. Using a longer time series since 1985 for the USDA Forest Service total to compare with the current forecast indicates suppression expenditures are forecast to be in the upper tercile.

The effects of drought were as expected, such that the drier the region in January of the current FY, the higher the suppression expenditures (West and East). In the West, the January positive value for ocean temperatures (Niño-3 sea surface temperature anomaly) reduces forecasted suppression expenditures while the positive value for the ocean pressure index (Pacific-North American teleconnection pattern) increases expected suppression expenditures. The West has been experiencing higher suppression expenditures in the years since FY 2000, and the RFS has higher suppression expenditures in the years since FY 2012.

Department of the Interior

The median forecast expenditure from the Monte Carlo simulation for the Department is in the middle tercile in real dollar terms compared to the observed expenditures since 1985 and since 1995. The outcome is the result of countervailing influences of a positive Niño-3 sea surface temperature anomaly (2.93), leading to lower expenditures; and higher average expenditures due to the upward shift in expenditures since 2000, and the influence of a slightly positive Pacific-North American teleconnection (0.78).

Table 1. March 2016 FLAME Act forecasts of FY 2016 suppression expenditures of the USDA Forest Service, by regional aggregate and in total in current year (FY 2016) dollars.

(Millions of 2016$)	West	East	RFS	Total FS
Median Estimate	683	68	528	1,279
80% Confidence Lower Limit	378	30	361	955
80% Confidence Upper Limit	988	106	694	1,604
90% Confidence Lower Limit	340	25	314	885
90% Confidence Upper Limit	1026	111	741	1,676
95% Confidence Lower Limit	321	23	273	827
95% Confidence Upper Limit	1045	114	782	1,733

Table 2. March 2016 FLAME Act forecasts of FY 2016 suppression expenditures of the USDA Forest Service by region and in total, probability of falling below specified amount in FY 2016 dollars.

Probability (%) of Falling Below Indicated Dollar Amount	West	East	RFS	Total FS
1	310	21	226	760
5	340	25	314	885
10	378	30	361	955
20	455	39	418	1,052
30	531	49	460	1,132
40	607	58	495	1,206
50	683	68	528	1,279
60	759	78	561	1,351
70	836	87	596	1,425
80	912	97	637	1,506
90	988	106	694	1,604
95	1,026	111	741	1,676
99	1,057	115	830	1,800

Table 3. March 2016 FLAME Act forecasts of FY 2016 suppression expenditures of the USDA Forest Service, by tercile

Region	Tercile of Costs Expected, Since 1995
West	Middle
East	Upper
RFS	Upper
Total FS since 1995	Middle
Total FS since 1985	Upper

Table 4. March 2016 FLAME Act forecasts of FY 2016 suppression expenditures of the Department of the Interior in FY 2016 dollars.

(Millions of 2016$)	
	Total DOI
Median Estimate	350
80% Confidence Lower Limit	266
80% Confidence Upper Limit	434
90% Confidence Lower Limit	242
90% Confidence Upper Limit	458
95% Confidence Lower Limit	221
95% Confidence Upper Limit	479

Table 5. March 2016 FLAME Act forecasts of FY 2016 suppression expenditures of the Department of the Interior probability of falling below specified amount in FY 2016 dollars.

Probability (%) of Falling Below Indicated Dollar Amount	DOI
1	197
5	242
10	266
20	295
30	316
40	333
50	350
60	367
70	384
80	405
90	434
95	458
99	503

Table 6. Ordinary least squares regression equation estimates used in the March 2016 forecast of FY 2016 suppression expenditures of the USDA Forest Service.

Dependent variable	Independent variables	Coefficient	Standard error	t-statistic	P-value	R^2	Durbin-Watson statistic
West Expenditures	Constant	342,834,123	78,248,231	4.38	0.0001	0.80	1.85
	Region 3 January Palmer Z-Index	-51,544,530	20,881,448	-2.47	0.0171		
	Years 2000 on	480,634,469	91,207,378	5.27	<.0001		
	Pacific North American Oscillation December (t-1)	181,821,724	43,653,729	4.17	0.0001		
	Niño-3 SSTA January	-111,217,427	41,078,257	-2.71	0.0093		
East Expenditures	Constant	5,006,099,739	1,964,026,654	2.55	0.0140	0.69	2.03
	East Expenditures (t-3)	-0.74	0.16	-4.76	<.0001		
	Time (in years)	-2,446,803	979,175	-2.50	0.0159		
	Region 9 January Palmer Z-Index	-12,789,311	5,940,904	-2.15	0.0363		
RFS Expenditures	Constant	167,784,664	27,525,464	6.10	<.0001	0.61	2.28
	Years 2012 on	342,378,000	63,068,761	5.43	<.0001		

Note: The dependent variable is the annual total real dollar suppression expenditures for each regional aggregate.

Table 7. Cross-validation of the ordinary least squares regression model used in the March 2016 FLAME Act forecast of FY 2016 suppression expenditures of the USDA Forest Service calculated over data from 1998-2015 in FY 2016 dollars.

	Millions of 2016 dollars	Percent
Root mean square error	229	-
Bias	(4)	-
Percent bias	-	(0.39)
Mean absolute percent error	-	19
Percent correct direction of change	-	89

Table 8. Equation estimates used in the March 2016 FLAME Act forecast of FY 2016 suppression expenditures of the Department of the Interior.

Dependent variable	Independent variables	Coefficient	Standard error	t-statistic	P-value	R^2	Durbin-Watson statistic
DOI Expenditures	Constant	190,519,797	15,048,201	12.66	<.0001	0.82	1.97
	Niño-3 SSTA November (t-1)	-30,543,159	9,788,061	-3.12	<.0001		
	Years 2000 on	197,351,165	21,044,004	9.38	<.0001		
	Pacific North American Oscillation December (t-1)	48,527,377	10,957,643	4.43	<.0001		

Note: The dependent variable is the Department's annual real dollar suppression expenditures.

Table 9. Cross-validation of the equation used in the March 2016 FLAME Act forecast of FY 2016 suppression expenditures of the Department of the Interior calculated over data from 1985-2015 in FY 2016 dollars.

	Millions of 2016 dollars	Percent
Root mean square error	65	-
Bias	5	-
Percent bias	-	1.64
Mean absolute percent error	-	20
Percent correct direction of change	-	82
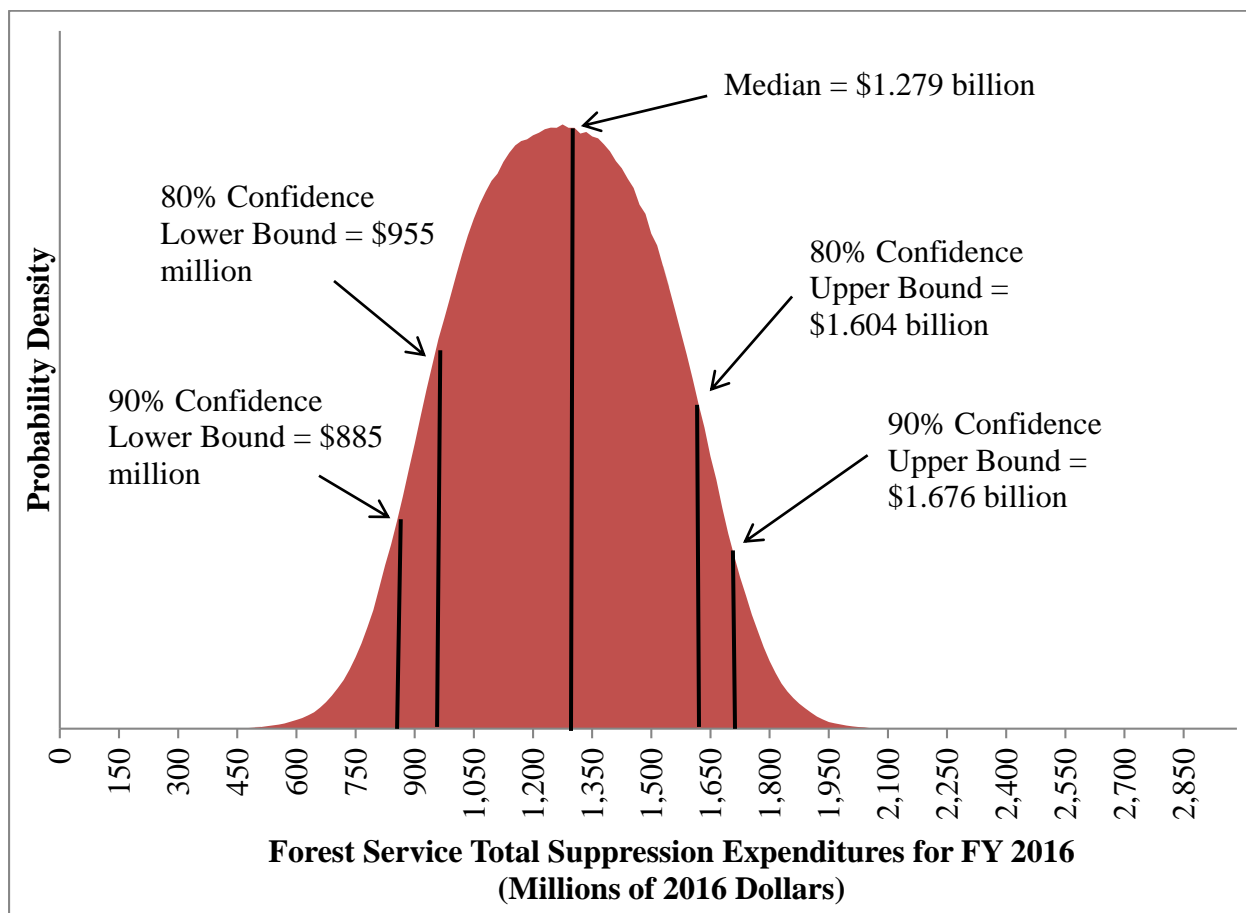
Figure 1. USDA Forest Service suppression expenditure forecast probability density, FY 2016, March 2016 FLAME Act forecast model.
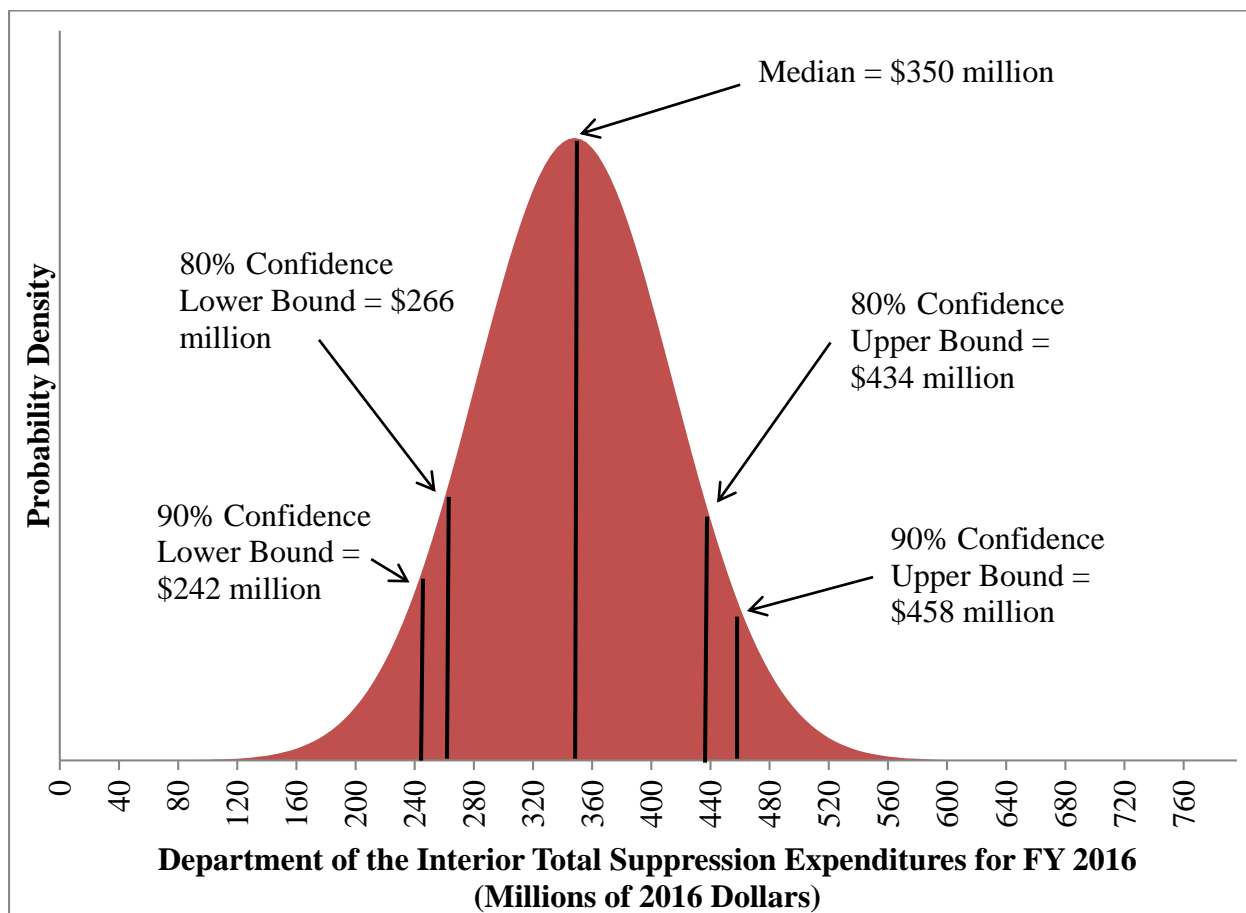
Figure 2. Department of the Interior suppression expenditure forecast probability density, FY 2016, March 2016 FLAME Act forecast model.
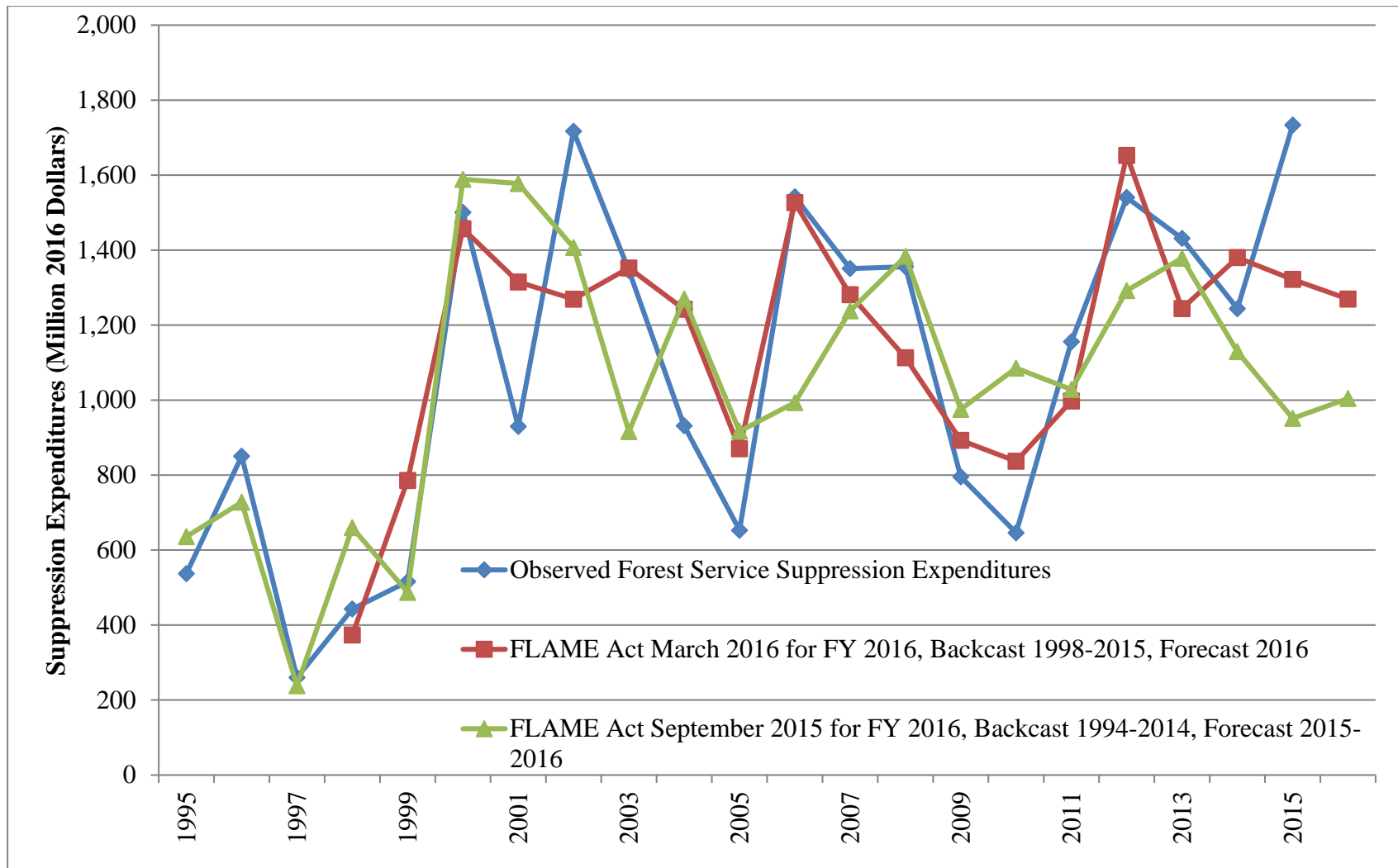
Figure 3. Observed historical USDA Forest Service suppression expenditures (1995-2015) and the forecasts of these expenditures (1998-2016), using the March 2016 FLAME Act Forecast Model. All forecasts for each fiscal year are sums across the point estimates of each region's expenditures generated with a cross-validation procedure. (Note: values are in constant 2016 dollars and include the wildland fire suppression cost pool expenditures.)
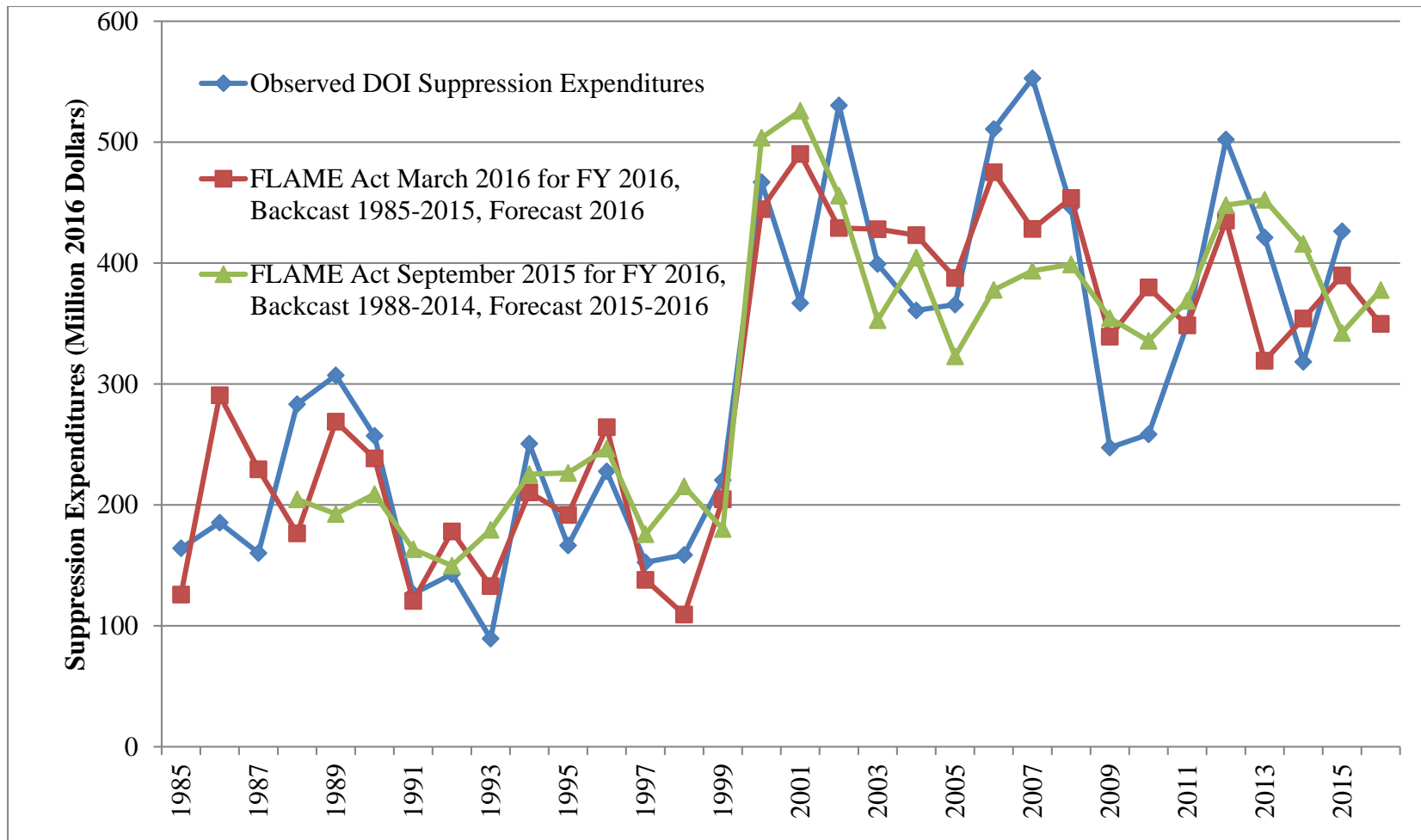
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Figure 4. Observed historical Department of the Interior suppression expenditures (1985-2015) and the forecasts of these expenditures (1985-2016), using the March 2016 version of the March FLAME Act Forecast Model. All forecasts for each fiscal year are the point estimates generated with a cross-validation procedure. (Note: values are in constant 2016 dollars)